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THE PRESENT AND FUTURE STATE OF OUR NATURAL RESOURCES[1]

ALMOST nineteen years ago I set foot for the first time upon American soil, and it is most interesting, after so long a time, to now renew acquaintance with American life and American universities. Much has happened since my first visit to the United States, and the World War has in many ways revolutionized our ideas, whether for better or for worse. One American characteristic, however, has evidently not changed, and that is your cordial hospitality, which I find to be as warm to-day as it was twenty years ago.

I wish first of all to express my very sincere appreciation of the honor of the invitation to come to Cornell University as an incumbent of the George Fisher Baker Non-resident Lectureship in Chemistry, that splendid endowment which can not be too highly prized, because it affords your students what we in Europe regard as one of the most important features of university life, namely, frequent contacts with investigators from foreign countries and with workers in various branches of science.

It was with great pleasure that I accepted the invitation tendered to me by the trustees of this university and by Professor Dennis and his colleagues, and my earlier experience in America convinces me that my stay at Cornell will remain one of my most pleasant recollections.

It has become a custom for your guest to devote this introductory lecture to the presentation of some topic of general interest which is not necessarily related to his later technical lectures, and I have chosen for my subject this evening "The Present and Future State of Our Natural Resources."

This is a question of great general interest, and is one in which the chemistry of our day is deeply involved. Archeologists have distinguished the different principal periods in the history of human civilization in a particular way, and have employed the terms the stone age, the copper and bronze ages, the iron age, etc., expressing in this manner their deep conviction that the state and future of the human race is, at every moment of its history, intrinsically connected with the special position in

[1] Introductory public lecture by Professor F. M. Jaeger, of the University of Groningen, non-resident lecturer in chemistry at Cornell University.

which man has been able to place himself with respect to his natural resources of materials and energy. This is true not only for the past, but equally so for our present-day world.

If we speak of "natural resources" in the most general sense of the word, we have in view both the material and the energetic resources of nature. The first are represented by the small or more extensive stocks of materials of varying kinds; coal, oil, iron, tin, ores of the heavier metals, many mineral and vegetable products, as potash, rubber, etc. Resources of energy, on the other hand, are certain natural stores that can directly be utilized for the production of mechanical force, or can easily be transformed into special forms of energy that can then be thus used. Waterfalls, the high and low tides of the sea, and solar radiation are examples of such resources of energy. It is not always possible to draw a sharp line of demarcation between the two categories, because "matter," as such, always represents also a certain stock of potential energy. Coal and oil, for instance, are only in small part utilized as raw materials; in by far the greater number of cases they are used as fuel, their energy of combustion being applied in our engines.

Let us now first consider the material resources. Everybody knows that our whole technical and industrial development depends upon the use of a certain number of indispensable raw materials. Technics and industry in their present aspect would be obliterated if the natural sources of supply of such metals as iron, copper, tin, lead, zinc, etc., should suddenly become completely exhausted. Dynamo and steam engine would in that case irrevocably disappear, just as the monsters of earlier geological epochs, the ichthyosaurus and the megatherium, vanished as soon as conditions became incompatible to their existence. Industry and traffic in their present form would become quite impossible. And the same is true, if the stores of coal and oil were no longer at our disposal. Attention has repeatedly been drawn to the fact that the danger of such a catastrophe is not very remote if we continue to squander our capital of raw materials in the reckless way that has been pursued in the past and indeed is even now being followed.

Jeans has recently sharply emphasized the fact that humanity in its present stage of development must, properly speaking, be considered as a "baby" only, if the still vast future existence of our race is taken into account—a baby, which hitherto has chiefly thought only of its nutrition and first physical growth, and which but recently has begun to look somewhat farther than its immediate environment. We must, however, acknowledge that during this very insignificant portion of its whole presumable existence, th same baby has already shown that it is extreme gluttonous, because in only 120 years it has fed o its natural resources in such an immoderate way a to cause anxiety concerning its future nourishme All countries are now beginning to understand th the material resources of the world are by no mea inexhaustible, and that it is urgently necessary t take measures to prevent further unrestrained de struction of them. Some numbers and graphs ma help to elucidate the present situation.

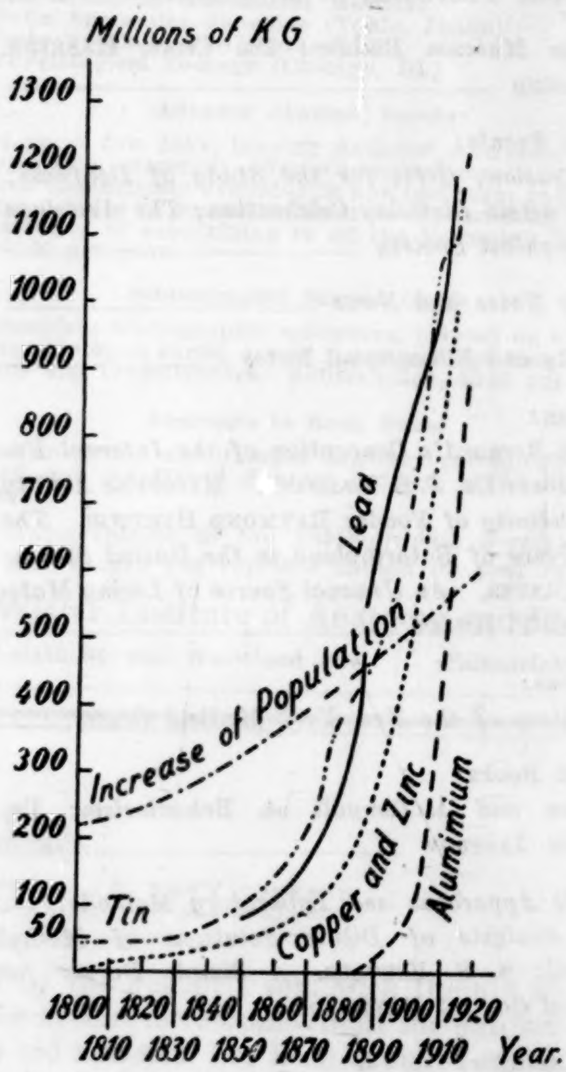

Fig. 1. Yearly increase of consumption of some Metals during the last 120 years.

In 1878 the annual world production of copper was 154 million kilograms; in 1892 it was 310 million; eight years later 713 million, and in 1917 1,413 million kilograms, about ten times the amount produced in 1878. Thus we see that the production of this metal has doubled about every nine years.

The annual world consumption of coal in 1840 was about 50 billion kilograms; in 1860 it was 200 billion; in 1880 460 billion, and in 1920 it had increased to 1,550 billion kilograms, or thirty-three times the consumption in 1840.

In 1860 about 96 million liters of mineral oil were produced; in 1870 eleven times that amount; in 1880, ty times, and in 1890 one hundred and fifty times that quantity. The present consumption has risen to the enormous figure of about 214 billion liters a year. The United States alone produces about three quarters of this tremendous quantity, and measures are now being taken to keep it stationary.

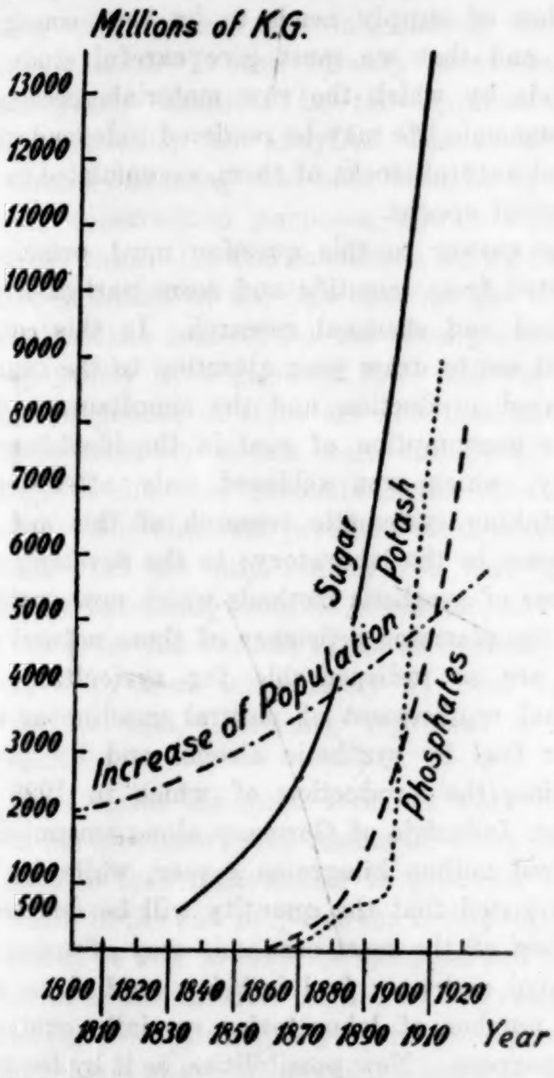

Fig. 2. Yearly increase of consumption of Sugar, Phosphates and Potash during the last 120 years.

In the same period of sixty-eight years, the production of Chile saltpeter has increased to one hundred and thirty times the original quantity; it is now about three billion kilograms a year.

The three graphs will give you an idea of the general rates of increase of the yearly consumption of several important metals, coal, sugar, phosphates, potash, etc., and of the analogous form of the corresponding curves in all cases. In some of these graphs there is also given a curve which indicates the increase of the world's white population. The striking difference between these two curves clearly shows that the yearly consumption of raw materials *per individuum* has increased in quite an alarming way. In Figure 4 the curves give a direct and impressive graphical representation of this increase of what I might call "the individual hunger for raw materials" of the present world.

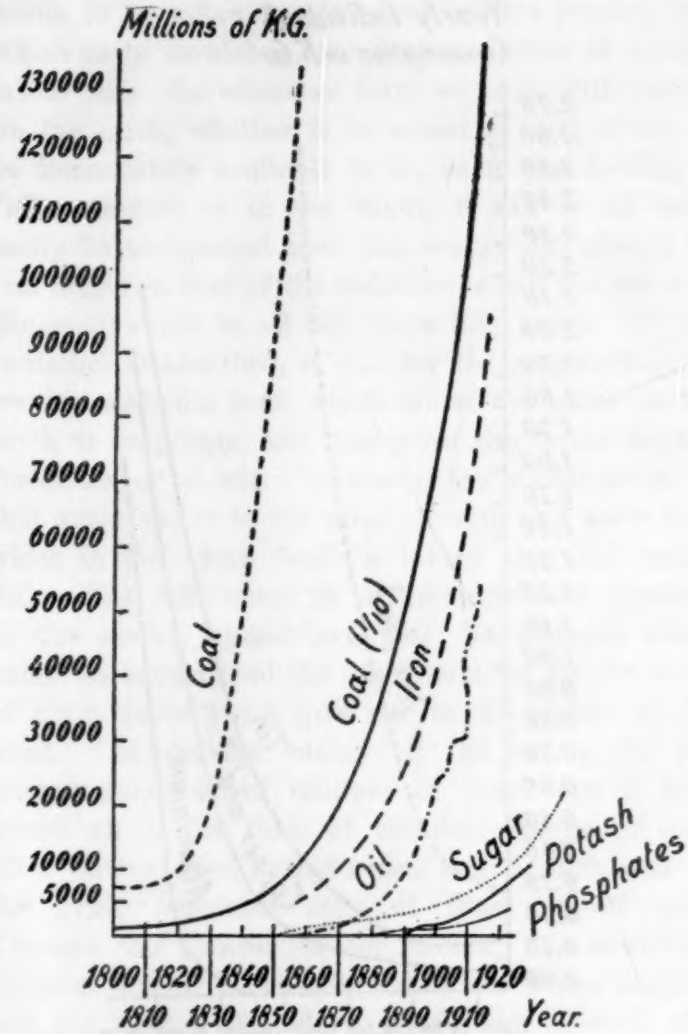

Fig. 3. Yearly increase of Coal, Iron and Oil during the last 120 years.

Many authors have already often emphasized the fact that if this rate of consumption continues, the world demand will increase within a hundred years to such enormous quantities that it will far surpass the available amount of some of these materials, such as tin and oil.

Perhaps some of you might raise the objection that, according to one of the fundamental laws of chemistry, matter is indestructible and that the quantities produced must, therefore, continue to remain in circulation. But this law is not applicable to our economic life because great quantities of these materials are forever lost every year by "wastage," and thus are withdrawn from circulation in forms from which they are not recoverable. This is true, as everybody will immediately grasp, not only for such substances as coal and oil, which are completely destroyed, but also for a great number of compounds

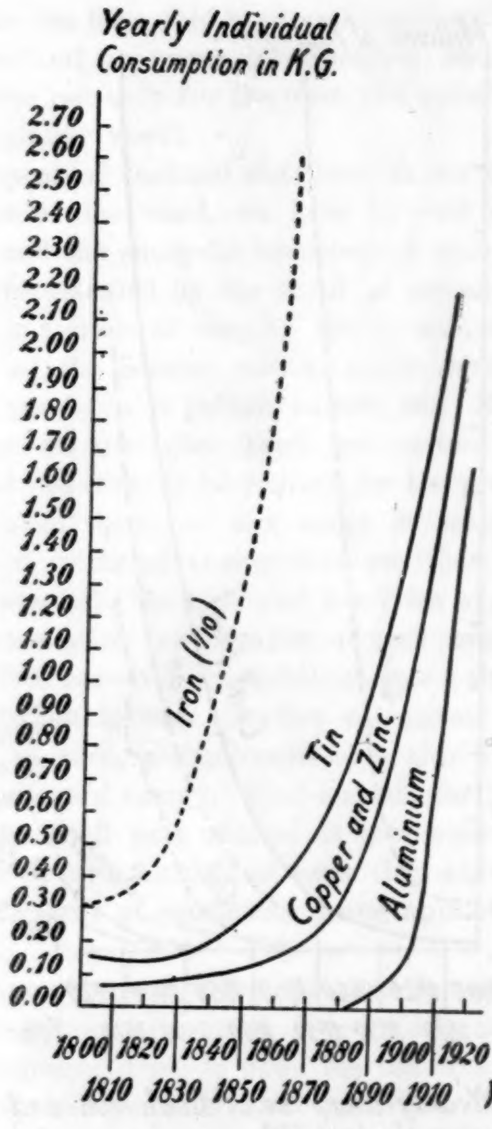

Fig. 4. Yearly Increase of the Consumption per Individual during the last 120 years.

of lead, zinc, tin and other metals, which, in the form of pigments or other chemical combinations, pass into the wastes of many industries and thus finally reach the sea. Very appreciable quantities of even the metals themselves are steadily lost beyond recovery.

As early as 1911 Sir William Ramsay, on the occasion of the meeting of the British Association for the Advancement of Science at Portsmouth, called attention to the fact that if English coal mining should go on at the rate of that moment, England, within 175 years, would no longer be able to provide itself with coal. B. W. Evermann in 1922, in an address before the American Association, gave a survey of the deplorable destruction of the forests of the United States, emphasizing the influence of it upon the water content of the rivers and on the change of the fauna in them. Several geologists are of the opinion that the stores of oil in the United States will, if consumed at the present rate, last no longer than forty or fifty years.

In 1921, upon the recommendation of the National Academy of Sciences, the American Association for the Advancement of Science and the National Research Council in this country, an Executive Committee on Natural Resources was created. This committee plans to make a continuous survey of the stocks of raw materials still present in America. All these facts clearly indicate that at last the conviction is more and more gaining ground that this vital question of supply needs to be kept constantly in view, and that we must give careful study to the methods by which the raw materials necessary for our economic life may be rendered independent of the limited natural stocks of them, accumulated in former geological epochs.

The answer to this question must principally be expected from scientific and more particularly, from physical and chemical research. In this connection permit me to draw your attention to the enormously increased production and the simultaneous decrease in the consumption of coal in the blast-furnace industry, which was achieved only after long and painstaking systematic research of this and related processes in the laboratory; to the development of a number of synthetic methods which now enable us to meet the alarming deficiency of those natural nitrates that are so indispensable for agriculture; to the gradual replacement of natural gasoline as a liquid motor fuel by synthetic alcohol and by "artificial" gasoline, the production of which in 1928 by the Farben Industrie of Germany alone amounted to one hundred million kilograms a year, while for 1929 it is estimated that the quantity will be doubled. The problem of the most economic way of using coal in industry and as a fuel is being studied on all sides in a number of laboratories specially equipped for that purpose. New possibilities, be it by the improvement of existing methods or by the development of completely new ones, are created every year in scientific and industrial laboratories. Numerous tests are continually being made as to the possibility of replacing many raw materials, hitherto considered indispensable, by others which will do as well or even better than the old ones. Thus, for instance, the use of metallic aluminum and its alloys for constructive purposes instead of the often more costly, heavier metals has increased very rapidly during recent years. In industry, and to a certain extent also in our daily life, measures are now taken to avoid the dissipation of raw materials by making use, in an appropriate way, of waste products formerly considered as valueless. It is worth remarking that an undeniable change of direction can be seen in the choice of raw materials for all kinds of purposes. The effect of this change is that the heavier metals

which, in general, are obtained by mining at the lower levels of the earth's crust, are being replaced by the less dense metals and other elements that are present in the upper layers of the lithosphere, and which, therefore, may with much less cost be obtained by surface-mining. Among those elements silicon, which in the form of silica represents 60 per cent., and aluminum, which, as its oxide and as other compounds, represents about 15 per cent. of the earth's crust, are, with calcium and magnesium, the most predominant ones. I have already mentioned the enormous yearly increase in the application of aluminum. Recently an alloy of this metal with silicon, termed "silumin," has been brought upon the market for construction purposes, and is replacing iron in many cases. In this connection let me further draw your attention to the fact that the use of concrete and Portland cement, for the same purposes, is increasing yearly at a gigantic rate, and the glass and other compounds of silica are now used in many cases where formerly metals were employed. That this change of direction necessitates the solution of many totally new chemical problems need hardly be emphasized. Let me only remind you here of the possibility of extracting metallic aluminum, not from bauxite but from the various kinds of ordinary clay which are everywhere immediately at hand on the earth's surface and, therefore, represent a much cheaper material.

Thus, it is again the quiet research work of the chemist in his laboratory, the results of which do not always seem to lead immediately to practical applications, which in the end prepares the fertile soil from which we shall be able to reap the technical and industrial victories of the future. As Lord Cecil remarked some years ago, it is principally by new conquests of nature that our society can gradually reach a higher level of life. Indeed, at the present time, as Sir William Bragg recently emphasized in his address to the British Association in Glasgow, industry is the slave of pure scientific research rather than its master. Every far-seeing government must set itself the task of supporting this scientific investigation by abundant endowments, because only new discoveries and their applications will be able to avert from mankind the ominous menace of an early shortage of our material resources, and the consequent impoverishment of our civilization.

Let us now consider the second category of natural resources, the energetic ones.

It is a well-known fact, that, both for the biological processes in plants and animals as well as for the maintenance of human civilization, a continuous import of energy from outer space to our planet is necessary. The only source of energy that practically needs to be taken into account in this respect, and which daily furnishes enormous quantities of energy, is our sun. In whatever form we meet with energy on the earth, whether it be stored in coal or oil, or be immediately available to us, as in the flowing or falling water, or in the winds, it can in all cases easily be understood that this energy has always its real origin in that of the radiation which the sun continuously emits in all directions into space. If this radiation is absorbed, it will for the greater part be transformed into heat, which causes the water on the earth to evaporate, and thus gives rise to the mighty formation of clouds. Inversely, the condensation of this water vapor is the cause of rain and snow fall, which in their turn feed the rivers, seas and waterfalls. The differences in temperature and pressure in the earth's atmosphere that are brought about under the influence of the solar radiation are the cause of air-currents which give rise to the energy of the wind. The radiant energy of the sun given out several hundreds of millions of years ago is now stored up in the form of chemical energy in coal, after having been transformed and accumulated in the living vegetable cells of those far-off eras. Through the process of combustion, this stored-up chemical energy is used by us in our steam engines and gas motors of to-day. This stock of coal, and also of mineral oil, nowadays represents the principal source of energy that man utilizes for the production of mechanical power. There is no other source of energy on the earth the output of which can even distantly be compared with that derived from the two sources just mentioned. We can safely say that practically our whole need of energy is supplied by that fossil stock of solar energy which is at present stored in our deposits of coal and oil. The necessary consequence of this is that we draw upon our energy capital to so great an extent that it must finally become exhausted, unless some way be found to replenish it by again accumulating this mighty solar radiation against the day when our stores of coal and oil will have been exhausted. The total quantity of coal on the earth seems not to exceed about 2,000 billion tons, of which at the present time about 1.5 billion tons are used annually. This yearly consumption, however, is increasing so rapidly that our coal deposits will hardly be sufficient for another thousand years, a period that is very short in comparison with the length of the future existence of mankind on the earth. But the exploitation of the coal deposits that still remain will become impossible long before that time, both for technical and for economic reasons. Within a period much shorter than these thousand years, the ominous consequences of the present reckless demolition of our coal fields will make themselves

seriously felt, for the simple reason that the coal must be extracted from ever deeper and deeper levels with consequent rapid increase of the cost of mining.

The question as to whether it then will be possible to obtain the indispensable energy from other sources on earth must, so far as can now be judged, be answered in the negative. Again at the instigation of Sir William Ramsay, the possibility of such an eventual development of other energy sources was in 1910 seriously investigated in England by a number of competent men. On that occasion the possibilities were taken into account of making use of the ocean tides, of the internal heat of the earth, of the energy of the winds and waterfalls, of the kinetic energy of the earth's rotation and of its yearly motion in space, of the chemical energy of wood and peat supplies, and finally of the intra-atomic energy of the atoms of the elements.

This official inquiry showed that the application of the internal heat of the earth, of the kinetic energy of the earth's motions, of the energy of the winds, and the use of wood and peat supplies never would be of any significance for the solution of the problem in comparison to the enormous quantities of energy yearly furnished by our resources of coal and oil. The energy that could be obtained by the disruption of the atoms of our chemical elements would be enormous in amount, but we need not further consider it at this time because in the opinion of our ablest scientists the practical accomplishment of this objective will be achieved only in the far distant future, if ever.

The available water-power on the earth would, according to Engler, amount to about the energy of seventy million tons of coal annually, *i.e.*, to about 4 per cent. of the energy necessary every year. Of course, the total water-power present on earth is much greater, but an appreciable part of it will probably never be available. A calculation made in 1922 by Steinmetz seemed to indicate that the energy of the flowing water, corresponding to the yearly amount of rain in this country, would be almost equivalent to that of your yearly coal consumption. Spoehr, however, has emphasized that these calculations are totally theoretical, as a great part of that energy is inaccessible and the distribution of the remaining energy over such an extensive territory would meet with almost insurmountable difficulties. Therefore, in this respect, America is, for the time being, dependent in a large degree upon her own resources of coal and oil, of which the latter seems to be rapidly approaching final exhaustion, notwithstanding the apparently reassuring fact that new sources of limited extent are frequently being developed.

The possible use of the low and high tides of the sea has occupied the attention of various inventors since the fifteenth century. Indeed, the periodically alternating low and high ocean tides would furnish gigantic quantities of energy if it were only possible to use them for mechanical purposes in a not too expensive and complicated way. In recent times several solutions of this problem have been proposed, some of which have already found a practical application, although only on a relatively small scale, in France, in England and in several places in Germany (Ditmarschen, Husum, Hüll). The systems with two large communicating water reservoirs, instead of those with a single one, seem to be preferable, as they allow an uninterrupted action both day and night, even during neap tide. Their theoretical efficiency, for a difference in sea-level of about three meters, is, however, less than that of a system with a single tank, and is not greater than about 4,800 kilowatts for each sea-tide and for each square kilometer of surface of the reservoirs, and in practice the efficiency is appreciably diminished by a number of uncontrollable factors, as, for example, the irregularities in the level-differences of the tides, to the square of which the energy output is proportional. Such a plant would be extremely expensive and its maintenance would be very costly. Consequently it could economically be operated only under very favorable local conditions. It is therefore probable that no satisfactory solution of the problem of the production of energy in this manner is to be expected.

Recently, however, there seems to be indicated another way of energy production from the sea which, in my opinion, may become of high significance in the future. I refer to the experiments of G. Claude and P. Boucherot upon the utilization of the relatively small but very constant temperature-differences that exist throughout the year between the sun-heated surface of the tropical oceans and their deeper layers, the temperature of which is kept at from 4° to 5° C. by the cold polar-sea currents. In 1913 your countryman Campbell pointed to the possibility of obtaining mechanical or electrical energy by means of these very constant temperature-differences, and in 1923 Romagnoli, Dornig and Boggia made analogous propositions. It was, however, only recently that the well-known French chemist Claude and his collaborator Boucherot succeeded in giving experimental proof of that possibility. They were able to demonstrate that a small Laval turbine designed to be driven by steam within pressure limits ranging from 20 to 0.2 of an atmosphere, can advantageously be driven by water vapor with tensions between only 0.04 and 0.01 of an atmosphere, corresponding to temperature-differences between 25° and

8° C. only. According to their calculations and experiments, a net output of 54,000 kilogram-meters could be obtained from each cubic meter of water between 28° and 5° C., if there be subtracted the energy that is necessary for pumping the cold and air-free water from the depth of the ocean to its surface. An installation of this kind having a capacity that effects the displacement of 1,000 cubic meters of cold water every second, would be able to produce 400,290 kilowatts of electrical energy, this efficiency being about thirty or thirty-five times as great as that of a low and high tide plant of the same dimensions. In their provisional installation at Ougree-Marihaye, Claude and Boucherot recently demonstrated before a meeting of engineers that a turbine could be run by utilizing the slight temperature-differences of the water of the Meuse, ranging only from 28° to 8° C., and that it could drive a dynamo with a capacity of fifty-nine kilowatts. The calculation by Boucherot of the necessary costs of installation seem undeniably to indicate that the practical realization of this idea lies very probably within the limits of technical possibilities.

The question as to whether it would be possible to use our present stocks of coal and oil in a more economical way than is now usually applied is of high importance and has often been the subject of discussion and investigation. In the present exploitation of our oil fields, about three fourths of the oil remains in the soil. This needs, in the future, to be recovered by some process suitable to the purpose. Even the continuous improvement of the steam engine, or its substitution by turbine or gas motor, can not eliminate the ominous fact that the greater part of the heat of combustion of the coal and oil will, when thus used, always be wasted. At the present time it seems that the most effective way of limiting, as far as possible, this squandering of energy consists in the combustion of the coal *in loco, i.e.,* at the mines themselves, and the immediate utilization of the heat of combustion for the production of high-tension electric currents. It is possible that some way may be found for transforming the potential energy of the coal directly into electrical energy, but experiments along this line have not yet met with practical success. None of the so-called "fuel batteries" constructed for this purpose in the last decade can be considered as being adapted to practical development, because their current efficiency, even at higher temperatures, remains in each case much too small by reason of the unsatisfactory reaction-velocity of the electrochemical processes going on in them.

As the matter now stands, we can say that in answering the question as to how to make the future necessary energy-production most completely independent of the fossil stocks of energy accumulated in former geological periods, we are chiefly confined to the mighty current of radiant energy that is flowing to us directly and continuously from the sun. This quantity of radiant energy appears to be stupendously great, but it is now almost completely lost by dissipation. Some data may give you a clearer understanding of this fact.

According to Langley's measurements of the solar constant, each square meter of the earth's surface receives, every hour, a quantity of radiant energy that is equivalent to 1,800 calories. If we regard the sun as limiting herself to an eight-hour working day in tropical regions, it can be calculated that every square meter of the earth's surface daily receives from the sun's radiation a quantity of energy equivalent to the heat of combustion of 1.3 kilograms of coal. For every square kilometer this is equivalent to 1,300,000 kilograms of coal, which means that the total annual amount of energy produced throughout the world through the combustion of coal would be equaled by the radiant energy of the sun which, during a like period, falls upon a surface of only 3,300 square kilometers (1,275 square miles). The desert of Sahara has a surface of about six million square kilometers (2.3 million square miles), and therefore annually receives a quantity of solar energy that is equivalent to more than 1,800 times that derived from the world's total yearly consumption of coal.

At present this enormous quantity of energy is almost completely lost; only three per cent. of it is absorbed and used by the living plants on the earth. Although this percentage is a very small one, the total quantity of radiant energy annually absorbed in this way over the whole solid surface of the earth still amounts to about fifteen times the yearly world consumption of coal. But the question arises as to whether and in what way it would be possible to catch the enormous quantity of solar energy that now is dissipated every year, and to apply it to the production of mechanical and electrical energy.

In the consideration of this question two points should be emphasized at the outset; first, the necessity of concentrating and accumulating the solar energy supplied to large surfaces; and second, of absorbing this solar energy to the greatest possible extent. Absorption must precede the transformation of radiant energy into those other forms in which it can be used for our immediate purposes. After absorption, the solar energy may be immediately transformed into heat which may then be utilized in the usual manner for the production of mechanical work, or the radiant energy may be absorbed by special substances in which it sets up a "photochemi-

cal" reaction and thereby produces a certain amount of chemical energy. This chemical energy can afterwards be changed into another form of energy suitable for our use. Nature has solved the latter problem of utilizing the solar energy through a most remarkable photochemical process in which that mysterious laboratory which we call the "living vegetable cell" is involved. The plant utilizes the radiant energy of the sun to synthesize a large number of complicated chemical substances in its protoplasm. These compounds accumulate in the plant organism, and their stored chemical energy can later be employed for the production of mechanical work. We also know of other photochemical reactions in which a fraction of the absorbed radiant energy is immediately transformed into electrical energy. I will discuss these more fully later on.

Let us first consider the other and simpler case of utilizing the solar energy by first concentrating and absorbing it, and then transforming it into heat.

Concentration of the radiant energy may be effected either by means of large lenses or by a system of mirrors; the absorbent heat-reservoir is placed at the focus. In actual practice, only systems of mirrors have been used. These are mounted on a light frame which permits them to be easily rotated, which is, of course, necessary because they must follow the apparent motion of the sun in the sky. The radiant energy concentrated by these mirrors falls upon a metallic reservoir which is blackened on the outside and which contains some volatile liquid that shows a considerable vapor tension at relatively low temperatures. Ammonia, sulphur dioxide or certain organic liquids of low boiling point are employed. An example of this type of installation is that devised by Schulz, in which, using sulphur dioxide, an output of about 1 H. P. was obtained for each square meter of surface of the absorbent reservoir. At the ostrich farm in Pasadena they have used, and perhaps still are using, a conical aggregate of mirrors of ten meters diameter, in the focal line of which a steam boiler was placed. This developed steam at a pressure of from ten to fifteen atmospheres after only one hour's exposure to the sun, and the device was used for pumping water at the rate of 6,000 liters per minute, and for driving a dynamo.

It may be possible that in dry and tropical climates this method of utilizing solar energy may be successful on a small scale, the cost of the equipment being compensated by the fact that the expense of operation is very low. But under less favorable conditions this device can never be expected to yield a satisfactory solution of the problem because it concentrates the radiant energy that falls on only relatively small surfaces. The proposal of Claude and Boucherot offers much greater promise in this respect because it utilizes the energy that is accumulated over the immense surface of the ocean during long intervals of time.

These considerations lead us to the conviction that the final solution of the problem must be sought rather in the utilization of specific photochemical reactions of the radiant energy. I intentionally use the word specific here because experience has shown us that the action of radiation upon chemical substances is highly exclusive in character. The assimilation of carbon dioxide by plants is a well-known example. The radiation is here absolutely necessary for bringing about this reaction which goes on at ordinary temperatures, the living cell bring able under the influence of sunlight and with the aid of its chlorophyll to synthesize a number of complicated substances which we in the laboratory, in spite of the high development of synthetic chemistry at the present time, are able to produce either not at all or only with great difficulty, even when high temperatures and powerful agents are employed.

We are still dependent, for the production of most of our foods and drugs, upon photochemical processes that proceed under the influence of solar radiation in the plant cells. Although it seems possible, according to the experiments of Ciamician and Ravenna, to influence these processes within certain limits by special external stimuli, we really as yet have little understanding of the true mechanism of these reactions. But the researches of Baly, which have shown that moist carbon dioxide may, in the presence of certain substances such as compounds of cobalt or nickel, be transformed through the influence of ultra-violet light into substances like sugar, have demonstrated that it is possible to produce, in the laboratory, compounds that are formed in the natural processes of the living plant. No one as yet has succeeded in carrying on this photochemical synthesis on a large scale. It offers, however, an alluring prospect because, according to Brown's investigations, if it is assumed that a quantity of solar energy equivalent to five calories will transform one liter of carbon dioxide into sugar, and if only 4 per cent. of solar energy during an eight-hour day is assumed to be photochemically active, it would be possible in this manner to produce 374 pounds of sugar every day by the use of a tank having a surface of only one hundred feet square. This amount of sugar, besides its value as a nutriment, would, if used as a fuel, be equivalent to about 154 pounds of coal. It is extremely doubtful, however, whether this method of utilizing solar energy will ever be brought to practical success.

The remaining possible solution of the problem of utilizing the radiant energy of the sun for the production of mechanical work is the application of reversible photochemical reactions which proceed in such a manner that the absorbed radiant energy may be converted into a usable form such as electrical energy. If the reversibility of such photochemical reactions is nearly quantitative in character, the photosensitive system of substances will then, in respect to solar radiation, play a rôle analogous to that of the lead accumulator in respect to electric energy. We might term such instruments "radiation accumulators"; they would be exposed during the day to the solar radiation which would cause a certain photochemical reaction, and then at night when left in the dark this reaction would reverse, the materials would return to their original condition, and the radiant energy absorbed during the day would be set free and stored up for mechanical uses.

It has long been known that such reversible photochemical processes really exist. For example, if a solution of mercuric chloride and ferrous chloride in water is exposed to light radiation, a reaction takes place in which certain amounts of mercurous chloride and ferric chloride are formed, a chemical equilibrium between the four salts being finally reached. If now this solution is placed in the dark, the substances will revert to their original form, and during this inverse reaction the radiant energy absorbed will be completely set free in the form of electrical energy. It is possible to obtain a tension of 0.17 volt by means of such a photochemical cell; consequently a dozen such cells joined in series will yield the current furnished by an ordinary lead accumulator.

Again, such a photochemical cell can be made by placing two platinum electrodes to an acidulated solution that contains potassium iodide and ferric chloride. When this cell stands in the dark, ferrous chloride and a certain amount of free iodine will be formed, the iodine remaining dissolved in the excess of potassium iodide. On exposing this cell to the action of light, the chemical equilibrium is displaced in the opposite direction, and potassium iodide and ferric chloride are regenerated. As with the previous cell the absorbed radiant energy is set free as electric energy.

Another remarkable example of a phenomenon of this nature is described by Rigollot. Two plates of red copper, each of them superficially covered with a thin layer of cuprous oxide, are placed in a saturated solution of sodium chloride. If now one of these plates is exposed to light radiation and the other is kept in the dark, an electric current passes through the wire that connects the two electrodes. This current continues as long as the exposure lasts. The whole system returns to its original state in the dark. If the other electrode is illuminated, the electric current produced in the circuit flows in the opposite direction.

These various experiments furnish definite proof that it is possible to convert radiant energy into electrical energy by means of reversible photochemical processes.

There is, however, one great drawback to the practical application of such a method, and that is the very low intensity of the electrical current that is produced. The electrical work that can be done, which is a product of the voltage and current intensity, is, therefore, in all cases only extremely small. The explanation lies in the fact that the reversible transformations which take place in these cells are characterized by very small reaction velocities, and consequently the energy that is carried off can not be resupplied by the photochemical reactions with sufficient rapidity. The photochemical effect appears in general to be the strongest in those cases of reversible processes in which the oppositely directed reactions are slowest, and because of this fact, some investigators are inclined to doubt whether the utilization of such radiation accumulators can ever be of practical value. This opinion may, however, prove to be unduly pessimistic. The construction of such cells is wholly a problem of reaction-kinetics. If it should prove possible to devise radiation accumulators or Volta-cells in which reversible and very rapid photochemical changes take place when radiation of such wave-lengths as are contained within the solar spectrum is employed, the problem of using solar radiation as a source of energy might be regarded as definitely solved.

We are, however, still far distant from this goal. Photochemistry is still in its infancy and it has not yet outgrown the stage of mere empirism. It is quite possible, however, that when man's existence becomes seriously menaced because of a shortage of energy, photochemistry will rescue him from his distress.

The protection of mankind from this danger rests chiefly upon the physicist and the chemist, and they must ever be on the alert to find solutions for these intricate problems that involve the very existence of our race.

F. M. Jaeger

Ithaca, N. Y.

A MASTER MUSEUM BUILDER

Frederic Augustus Lucas, 1852–1929

In presenting some account of the scientific activities of Frederic Augustus Lucas we seem to be justified in giving him the rather old-fashioned title of nat-

uralist, rather than that of zoologist or anatomist. His almost life-long connection with museum work in four celebrated institutions gave him an unusually wide knowledge in the field of natural history. Many voyages in boyhood to far-away countries with his master-mariner father were, in his case, good preparation for the work he was to do, and to which, in fact, he was very early inclined.

It is fifty years since I found him in charge of the extensive work of preparing museum exhibits then going on in Ward's Natural Science Establishment. Whether the French preparateurs were engaged in osteological, taxidermal or other lines, they all submitted loyally to his judgments, as he explained his criticisms in their own language.

A score or more of well-known naturalists who found their way to Rochester at different times as amateurs are indebted to him for useful training in museum methods.

His genius in that direction was strongly developed. Although most of them, like Lucas himself, had common-school education only, they eventually secured recognition in the field of natural science.

While college training undoubtedly has its advantages, the young man who knows what he wants to do and is persistent can make headway without it. Lucas believed in manual training. His skill with small tools and his drawing were excellent. Angling was his favorite outdoor recreation, and the rods he made himself were the equals of those sold in the shops. He helped me mount my first tortoise, and for separating carapace from plastron, quickly riveted a small saw blade in the handle of a toothbrush, making an instrument that has been serviceable for light sawing purposes ever since. Humorous and kindly as he was, those who worked with him can not forget his ever-ready helpfulness.

He went to the National Museum in 1882, where notable exhibits in osteology, paleontology and the results of other labors as curator remain as his monuments. His work as curator-in-chief of the Brooklyn Museum, to which he was called in 1904, was distinctly that of an up-builder.

Recognized as an ideally equipped museum officer by reason of his curatorial successes, he was called in 1911 to the directorship of the American Museum of Natural History, where many instructive installations bear witness to his scientific knowledge and good taste. It is important to note that his associates everywhere greatly valued his opinions.

There was another side to the character of Dr. Lucas which we find of greater interest than the official positions he so ably filled. Stevenson says—to quote from memory—if a man love the occupation that supports him, the gods have called him. Intensely devoted to his daily work and his natural history studies, Dr. Lucas dwelt under a happy star. Since he had a taste for the best literature and was naturally studious and decidedly gifted as a writer, his published papers remain as permanent contributions to the subjects he strove earnestly to elucidate.

He took many an effective shot at scientific errors as they flew, without anybody's feelings being hurt by his marksmanship. He had a genial way of winning out in his controversies.

During the late nineties, while he was my neighbor in Washington, his regular evening occupation was the preparation of zoological articles for Johnson's "Universal Cyclopaedia," then being published in eight volumes. Having had this work within reach ever since, I find it easy to testify to the value of his contributions thereto.

While his writings are to be found chiefly in scientific journals and government documents, he provided two books for the publisher—"Animals of the Past" and "Animals Before Man in America."

We were associated in the fur-seal investigations of 1896–97 in Bering Sea, where Dr. Lucas undertook anatomical studies having an important bearing on certain matters of international controversy, with the result that vital claims made on the American side were substantiated.

He greatly enjoyed the prolonged struggle over the Bering Sea question, and exclaimed again and again, "We shall beat them on that point." Commenting on the way that matters already well disposed of wouldn't stay put, he quoted, "Per aspera ad astra," and provided an additional demonstration.

We have known no more gifted critic in the field of museum effort. Few curators can point to more illuminating labels than those he wrote by the hundred.

Since these lines are written at sea, with no opportunity to look up his scientific papers for comment, it is impossible to make this sketch what it should be.

CHAS. HASKINS TOWNSEND
NEW YORK AQUARIUM

SCIENTIFIC EVENTS

SOIL EROSION

MR. HUGH HAMMOND BENNETT reports to the U. S. Department of Agriculture that more than 513,000,000 tons of soil are being washed out to sea each year from the farms of the United States, and the Mississippi River system alone is responsible for 428,000,000 tons.

Mr. Bennett states that this is a minimum estimate for the Mississippi. More comprehensive methods of measurement devised recently indicate that

these figures do not allow adequately for the heavier material carried along the bed of the river. Neither does this estimate take into account the fact that a great deal more material is washed out of the fields than ever reaches the sea. Much is stranded on the way and causes inconvenience to man by creating sandbars, filling up river channels, covering fertile fields with flood débris and the like.

This continuous and heavy loss of the soil on which the very food supply of the nation depends is a most important problem that has to do with the use of our most vital resource—the land. To confine the menace within the bounds of reasonable safety will tax the best efforts and ingenuity of the nation.

Terracing the fields, contour ploughing and cultivation, wise forestry management, the conservation of forestry or grazing of sharply sloping lands that are sure to wash away if cultivated, and scrupulous attention to gullies while they are small to prevent enlargement are parts of the answer to this problem. The problem is so important that it demands the best cooperative effort of engineers, of chemists and physicists among the soil scientists and of practical farmers.

On the basis of the chemical analysis of nearly 400 surface soils it may be estimated that the amounts of material washed away from the fields of the country each year contain not less than 126,000,000,000 pounds of plant food. This is a loss about twenty-one times the annual net loss of plant food taken out of the fields by all the crops that are harvested. In a soil depleted of one or more of the elements of plant food essential to growth, it is usually possible to supply this in the form of fertilizer. But when the soil has been washed away the use of fertilizer is not effective. Measured on the basis of chemical analysis, the value of the phosphorus, potassium and nitrogen contained in the material washed from the fields each year would cost something in excess of $2,000,000,000 if purchased at current market prices for the cheapest commercial carriers of these three essential plant foods.

GIFTS FOR THE STUDY OF DEAFNESS

Gifts amounting to $91,080, bringing the fund for research into the causes and methods of preventing deafness up to more than a quarter of a million dollars, have been announced by Dr. Arthur B. Duel, chairman of the board of trustees of the American Otological Society. This is half the amount which the society proposes to raise before July 1 in order to continue the studies started under a grant made by the Carnegie Corporation.

The research to which this fund is to be applied is being conducted by otologists in different medical and educational institutions throughout the country, including the Harvard Medical School, Northwestern University Medical School and the Massachusetts General Hospital. A central bureau for direction of the research has been opened at the New York Academy of Medicine.

In commenting upon the importance of the investigation which the society hopes to make with this fund Dr. Duel said that the wide prevalence of deafness and the social and economic handicap it places upon a patient make this medical problem a particularly acute one. It has been estimated by some authorities that one out of every twelve persons suffers from some sort of ear affection.

The quarter of a million dollars which has been contributed or pledged to date includes a number of conditional gifts which will only be paid if the goal of half a million is reached by mid-year. One of these is a sum of $100,000 promised by Mr. Edward S. Harkness.

All the gifts are to become a part of the permanent fund of $2,500,000, which will be devoted to the study of diseases and affections of the ear in the hope of discovering methods of dealing with the problem of chronic progressive deafness.

The names of those whose recent contributions to this fund were announced include: Miss Isabel Valle January, $25,000; The Lillia Babbitt Hyde Foundation, $25,000; Mrs. Clarkson Cowl, $6,000; Mrs. William H. Moore, $5,000; Felix Warburg, $5,000; George F. Baker, $2,500; B. M. Baruch, $2,500; Mr. and Mrs. Pierre S. du Pont, $2,000; James D. Black, $1,000; Dr. Ogden M. Edwards, Jr., $1,000; Mrs. Frank C. Lowden, $1,000; Mrs. Richard March Hoe, $1,000; Mrs. John G. McCullough, $1,000; Dr. and Mrs. Lewis R. Morris, $1,000; Mrs. Herbert N. Straus, $1,000; Miss Gertrude S. T. Thomas, $1,100; Miss Emma C. Watkins, $1,000; Mrs. Walter O. Whitcomb, $1,000.

THE EINSTEIN BIRTHDAY CELEBRATION

The fiftieth birthday of Professor Albert Einstein was the occasion of a celebration in New York City on the evening of April 16. The celebration was held under the auspices of the Jewish National Fund and the Zionist Organization of America. Messages were received from President Hoover, the Earl of Balfour and from the leading universities of America.

President Hoover was represented at the meeting by Ray Lyman Wilbur, Secretary of the Interior, who made the principal address. Other speakers included Mayor Walker, Count F. W. von Prittwitz, German Ambassador to the United States; Louis Marshall, Nathan Straus, Rabbi Abba H. Silver, Dr. John Haynes Holmes, Emanuel Neumann, Morris

Rothenberg, the Reverend Z. H. Masliansky and Herman Bernstein, chairman of the Einstein jubilee committee.

Messages of tribute were read from Lord Balfour, President John Grier Hibben, of Princeton University; Dr. Julian Morgenstern, president of the Hebrew Union College, Cincinnati; Chancellor E. L. Lindley, of the University of Kansas; Chancellor E. A. Burnett, of the University of Nebraska; Judge Benjamin N. Cardozo, President David Kinley, of the University of Illinois; Professor A. A. Michelson; President James Rowland Angell, of Yale University; President C. C. Little, of the University of Michigan; President Wallace W. Atwood, of Clark University, and others.

It was announced at the celebration by Mr. Bernstein that the greetings received from the various men of science and other leaders of thought will be bound into a special album which will be presented to Professor Einstein.

Each of the Jewish signatories of the album contributed $100 toward the acquisition of land in Palestine by the Jewish National Fund, a project in which Dr. Einstein is interested.

Mr. Hoover wrote:

Professor Einstein ranks high among the foremost scientists of all time, who have enriched mankind by their invaluable contributions to thought and human progress. Every important scientific achievement is a step forward in the direction of better universal understanding and good-will. It is very fitting that distinguished educators and other public-spirited Americans are paying this tribute to Professor Einstein.

Lord Balfour, formerly Prime Minister of England, sent the following cable message:

I congratulate the organizers of the Einstein celebration upon the honor they are conferring on a great investigator. He profoundly modified scientific conceptions of the material universe. His name will be remembered through the ages as among the greatest of those who have sought pure knowledge for its own sake and have found it.

THE AMERICAN PHILOSOPHICAL SOCIETY

AT the annual meeting of the American Philosophical Society, held in Philadelphia from April 18 to 20 officers were elected as follows:

President

Francis X. Dercum, Philadelphia

Vice-presidents

William W. Campbell, University of California
James H. Breasted, University of Chicago
Elihu Thomson, General Electric Company

Secretaries

Arthur W. Goodspeed, University of Pennsylvania
John A. Miller, Philadelphia

Curator

Albert P. Brubaker, Jefferson Medical College

Treasurer

Eli K. Price, Philadelphia

Councilors

(To serve for three years)

Charles B. Davenport, Carnegie Institution
William H. Hobbs, University of Michigan
Emory R. Johnson, University of Pennsylvania
Harlow Shapley, Harvard College Observatory

Members

(Residents of the United States)

William F. Albright, Jerusalem, Palestine
Harley H. Bartlett, University of Michigan
George Henry Chase, Harvard University
James Pyle Wickersham Crawford, Philadelphia, Pa.
William Darrach, College of Physicians and Surgeons, Columbia University
C. J. Davisson, Bell Telephone Laboratories
Charles Hall Grandgent, Harvard University
John L. Haney, Central High School, Philadelphia
E. Newton Harvey, Princeton University
Edwin P. Hubble, Mount Wilson Observatory
William Jackson Humphreys, U. S. Weather Bureau
Solomon Lefschetz, Princeton University
James Howard McGregor, Columbia University
Michael I. Rostovtzeff, Yale University
Frank W. Taussig, Harvard University
Owen D. Young, New York, N. Y.

SCIENTIFIC NOTES AND NEWS

THE gold medal of the Linnean Society of London has been awarded to Professor Hugo de Vries, of Lunteren, Holland.

IN connection with the meeting of the American Chemical Society at Columbus, Ohio, a dinner will be given on the evening of May 2 in appreciation of the work of Dr. William McPherson, professor of chemistry in the Ohio State University.

THE sixty-fifth birthday of Dr. Harvey Cushing, professor of surgery at the Harvard Medical School and surgeon-in-chief of the Peter Bent Brigham Hospital, Boston, was celebrated on April 8. For this occasion a birthday book was compiled by his students. It differs from previous "Festschrifts" in that only those who could legitimately call themselves pupils have been included. Eighty-two articles are contributed by them to the volume, which contains 1,110 pages, forming the April issue of the *Archives*

of *Surgery*, so that the papers will be recorded in current medical literature. On April 6 the book was presented to Dr. Cushing in the presence of his pupils and family in the laboratory of surgical research of the Harvard Medical School.

THE King of Italy has conferred the decoration of Officer of the Crown of Italy upon Dr. Raymond Pearl, director of the Institute for Biological Research of the Johns Hopkins University.

To commemorate the discovery by President Hoover of Pawhuska limestone, a monument of the limestone will be erected by the Geological Survey of Oklahoma and will be dedicated to him.

EX-PRESIDENT COOLIDGE has accepted an invitation to become a member of the board of trustees of the National Geographic Society.

AT a meeting of the Franklin Institute of Philadelphia, on April 17, the Board of City Trusts presented a John Scott medal and premium to Dr. Lee de Forest, a member of the institute, for his development of the audion. At the same meeting Dr. W. F. G. Swann, director of the Bartol Research Foundation of the institute, gave a report on the year's activities of the institute.

DR. WILLIAM H. ROBEY, clinical professor of medicine at the Harvard Medical School, has been elected a fellow from Massachusetts of the American College of Physicians.

IN the presence of the king the University of Oslo commemorated on March 6 the one-hundredth anniversary of the death of the Norwegian mathematician Abel. Several foreign mathematicians were given honorary degrees, including Mr. Godfrey Harold Hardy, Savilian professor of geometry at the University of Oxford, and M. Paul Painlevé, member of the French government and professor of analytical mechanics at the University of Paris.

DR. W. V. BINGHAM, of the Personnel Research Federation, New York City, and Professor M. S. Viteles, of the University of Pennsylvania, have been elected honorary correspondents of the British National Institute of Industrial Psychology.

SIR ST. CLAIR THOMSON has been elected a foreign correspondent of the Paris Academy of Medicine.

PROFESSOR ARTHUR SMITHELLS has been elected president of the British Institute of Chemistry.

DR. EUGENE L. OPIE, director of the department of pathology of the University of Pennsylvania and of the laboratory of the Henry Phipps Institute, Philadelphia, has been elected a member of the board of scientific directors of the Rockefeller Institute for Medical Research.

WE learn from the *Journal* of the Washington Academy of Sciences that the emeritus professors of the George Washington University were entertained at a luncheon in their honor by President Cloyd Heck Marvin on March 26 at the Cosmos Club. Included in the company were the following men of science: James Howard Gore, mathematician and astronomer; Harry Crècy Yarrow, formerly curator of the Division of Reptiles of the U. S. National Museum, for thirty years acting assistant surgeon of the U. S. Army; Daniel Kerfoot Shute, ex-president of the Medical Society of the District and of the Society of Ophthalmologists and Otologists of Washington; William Kennedy Butler, physician; Charles Edward Munroe, inventor of smokeless powder, chief explosives chemist of the U. S. Bureau of Mines; Charles Williamson Richardson, ex-president of the Medical Society of the District; George Perkins Merrill, curator of the department of geology of the U. S. National Museum, and Sterling Ruffin, physician.

THE Alice Freeman Palmer Memorial Fellowship of the American Association of University Women has been awarded to Emma Perry Carr, professor of chemistry at Mount Holyoke College. Professor Carr, with Dr. Victor Henri, will complete a monograph on absorption spectra. The Margaret E. Maltby Fellowship has been awarded to Dorothy Richardson, who is working in experimental embryology for the degree of doctor of philosophy at Yale University.

THE appointment of Mr. Charles J. Rhoads, of Philadelphia, as commissioner of the Indian Bureau, has been confirmed by the Senate.

JAMES O. CLARKE, of the U. S. Department of Agriculture, has been promoted to the position of chief of the central district of the Food, Drug and Insecticide Administration, with headquarters at Chicago, to fill the vacancy created by the resignation of E. H. Goodnow.

SAMUEL T. WOODRING, who has served as chief ranger of the Yellowstone National Park for more than seven years, has been appointed superintendent of the new Grand Teton National Park.

DR. D. SINITSEN, of the zoological division of the U. S. Department of Agriculture, will make his headquarters at the University of California branch of the College of Agriculture at Davis, where, in cooperation with Dr. Robert Jay, he is making an investigation on the liver fluke.

A. B. MCMANUS, senior engineer (nautical) of the Hydrographic Office, has been appointed a delegate to the Fourth Pan-Pacific Science Congress to be held at Batavia, Java, in May. He will leave by way of San Francisco and return by way of Europe.

At the congress Mr. McManus will represent the Hydrographic Office on the committee dealing with general oceanographical subjects, such as configuration of the ocean bottom, bathymetric charting, tides, currents, ocean temperatures, etc. Captain Richard A. Warner, Medical Corps, U. S. Navy, now on duty as a member of the U. S. Naval Mission to Brazil, has been designated as a delegate in the division of hygiene, microbiology and pathology, and also to the Second Pan-American Congress on Tuberculosis, which will be held at Rio de Janeiro on June 30.

DR. P. S. KUPALOV, of the Institute of Experimental Medicine, of Leningrad, a colleague of Professor Ivan P. Pavlov, will be associated with the department of physiology and biochemistry of the Ithaca division of the Cornell University Medical College during the months of July, August and September. He will cooperate in an investigation of conditioned reflexes, which has been financed by the Heckscher Research Foundation. He will also conduct a seminar on conditioned reflexes during the summer session. Dr. Kupalov holds a fellowship of the International Education Board and is at present working in the laboratory of Professor A. V. Hill.

DR. GUSTAV KAFKA, professor of psychology in the University of Dresden, has accepted an invitation to become visiting professor of psychology at the Johns Hopkins University for the winter semester of 1929–1930.

SIX foreign psychologists, Professors Robert H. Thouless, Wolfgang Köhler, James Drever, L. Wynn Jones, F. Roels and F. Aveling, will give a series of lectures in the Universities of Michigan, Wisconsin, Minnesota, Iowa, Missouri and Pittsburgh during the coming summer session. Each visitor will spend one week in each of the institutions, thus covering the circuit in six weeks. The lectures will center about the subject, "Points of View in Psychology." These men are coming to this country primarily for the purpose of attending the International Congress of Psychology in September.

LYNDON L. HARGRAVE, of the Museum of Northern Arizona, Flagstaff, and A. E. Douglass, director of the Steward Observatory of the University of Arizona, have returned from a field trip to the ruins of Coconino and Navajo Counties, where they selected sites for later exploration.

DR. HAROLD C. BINGHAM, of Yale University, will conduct this summer a joint expedition undertaken by Yale University and the Carnegie Institution of Washington, to study the mountain gorillas of the Albert National Park, recently set apart by the Belgian government as a wild life sanctuary.

PROFESSOR HUBERT LYMAN CLARK, of Harvard University, accompanied by Mrs. Clark, sailed from San Francisco on March 29, on his way to Australia *via* Japan and Java. He is a delegate from Harvard University and from the American Society of Naturalists to the Fourth Pan-Pacific Scientific Congress which meets at Batavia from May 16 to June 5. Immediately after the close of the congress he goes to Australia, where he will begin as a research associate of the Carnegie Institution of Washington an investigation into the echinoderm fauna. The Museum of Comparative Zoology at Harvard University and the Australian National Research Council are cooperating with the Carnegie Institution in the promotion of this research. Dr. Clark expects to return to Cambridge about February 1, 1930.

IN connection with the investigation of exotic plants in the United States, Professor John W. Harshberger, of the University of Pennsylvania, will visit Australia and New Zealand this summer.

E. P. KILLIP, associate curator in the U. S. National Herbarium, A. O. Smith and W. J. Dennis have left for northern Peru and the upper Amazon, where they expect to spend seven months in explorations.

DR. ZAPPI, of La Plata, and V. Morera, instructor in biological chemistry at Buenos Aires, are members of a group of professors and scientific men who plan to visit some of the technical and teaching centers and institutions of the United States.

DR. ROBERT A. MILLIKAN, of the California Institute of Technology, has accepted an invitation from Dr. Thomas S. Baker, president of the Carnegie Institute of Technology, to give the commencement address at the institute on June 11.

"THE Air and its Ways" and "Fogs and Clouds" were the subjects of Sigma Xi lectures given by Dr. W. J. Humphreys at the University of North Carolina on April 12 and 13.

PROFESSOR G. A. MILLER, of the University of Illinois, lectured recently on the history of mathematics at the University of Michigan, under the auspices of the Michigan section of the Mathematical Association of America.

DR. E. J. KRAUS, of the department of botany of the University of Chicago, spoke before the Kansas State Agricultural College chapter of Gamma Sigma Delta, the honor society of agriculture, on April 5. His subject was "The Relation between Plant Physiology and Agriculture."

DR. H. M. JOHNSON, senior fellow of the Mellon Institute of Industrial Research and director of the

Simmons Investigation of Sleep, lectured on March 27 at the University of Missouri, under the auspices of Alpha Pi Zeta, on "The Persistence of Sorcery in Modern Science" and on "The Measurement of Sleep."

Dr. John C. Slater, assistant professor of physics at Harvard University, delivered a series of lectures in the department of physics of the University of Kentucky during the week of April 8 to 12, inclusive. The entire series of lectures was on the subject of "Wave Mechanics."

Dr. Paul R. Heyl, of the Bureau of Standards, Washington, delivered on April 6 an address before the Royal Canadian Institute, Toronto, on "Weighing the Earth."

Dr. Arthur S. Loevenhart, professor of pharmacology and toxicology at the University of Wisconsin, died on April 20, in his fiftieth year.

Dr. Thomas F. Scott, of Aberdeen, who was for many years connected with the Scottish Fishery Board and who is known for his investigations on marine crustacea, died on February 28 in his eighty-ninth year.

Nature announces the death of the Right Honorable Lord Avebury, on March 26, at the age of seventy years, and of Lord Montagu of Beaulieu, on March 30, at the age of sixty-two years. Lord Avebury was a trustee and also the honorary treasurer of the British Science Guild, and Lord Montagu was president of the guild in 1920–22.

The death is also announced of the British surgeon Sir A. A. Bowlby, at the age of seventy-three years, and of Sir Henry Rew, the statistician and agricultural expert, at the age of seventy years.

The *Journal* of the American Medical Association reports that a tricentennial service in honor of William Harvey was conducted in the Nakayama Culture Institute in Tokyo in December. Original copies of the "De motu cordis et sanguinis in animalibus," published at Frankfort-on-the-Main in 1628, and "Exercitationes de generatione animalium," 1651, were exhibited in the hall of the institute. The memorial lectures were "Recollections of Harvey," by Dr. H. Uagai, professor in the Tokyo Imperial University, and "The Works of Harvey," by Dr. Y. Teruoka, director of the Ohara Institute. Robert Koch's birthday was also celebrated by Baron Dr. Kitasato and his friends at the Jiji Hall, Tokyo. The memorial lectures were delivered by Dr. S. Uyematsu, professor in the Keio Medical College, on "Feelings and Effects Received from Koch" and by Dr. M. Miyajima on "The Friendship between Koch and Kitasato."

An International Meteorological Congress will meet at Havana in 1930. The chief subject to be discussed will be plans for defense against tropical hurricanes.

The twenty-fourth annual meeting of the American Association of Museums will be held in Philadelphia on May 22, 23 and 24, at the same time and place as the meeting of the American Federation of Arts. Headquarters will be at the Bellevue-Stratford Hotel.

The American Association for the Study of Allergy will hold its next annual meeting in Portland, Oregon, on Monday and Tuesday, July 8 and 9, at the time of the meeting of the American Medical Association. Further information may be obtained from the secretary, Warren T. Vaughan, Medical Arts Building, Richmond, Virginia.

The twenty-first annual meeting of the Poultry Science Association will be held from August 20 to 23 at the Alabama Polytechnic Institute at Auburn. Professor J. E. Ivey, head of the poultry department, is chairman of the program committee.

The fifth annual meeting of the Pennsylvania Academy with a full program was held at Pennsylvania State College during the Easter vacation. Officers for the coming year were elected as follows: *President,* Dr. Robert T. Hance, of the University of Pittsburgh; *Vice-president,* Dr. D. S. Hartline, Bloomsburg State College; *Secretary,* Dr. T. L. Guyton, Pennsylvania Department of Agriculture; *Treasurer,* Dr. H. W. Thurston, Pennsylvania State College; *Editor,* Dr. R. W. Stone, Pennsylvania State Geological Survey. Bloomsburg was chosen as the place for the next meeting.

The spring meeting of the American Society of Mechanical Engineers will be held at Salt Lake City from July 1 to 4. A party leaves New York on June 17, stops in Chicago for a sightseeing tour and then proceeds to Colorado and the Rocky Mountain National Park. Three days are spent there and five at Grand Canyon, Zion National Park and Bryce Canyon, before going on to Salt Lake City. From there the group continues northward to West Yellowstone, Butte and Great Falls, Montana, where there will be an opportunity to visit the copper mines. The last of the parks to be visited is Glacier, in western Montana. It abuts the Canadian boundary, where Waterton Lakes Park joins the Glacier National Park.

Senator James Couzens, of Michigan, has created a trust fund of $10,000,000 "to be used to promote the health, welfare, happiness and development of the children of Michigan, primarily—and elsewhere in the world." A clause in the trust instrument stipulates that the principal and income must be disbursed in its entirety inside of twenty-five years. The instrument also provides that should expenditures in

any fiscal year fall below this amount the unexpended portion must be spent the succeeding year.

THE Rockefeller Foundation has offered, through Princess Helen, mother of King Michael, to establish a national hygienic institute in Bucharest to combat social diseases. The offer was made contingent upon the Roumanian government bearing half the expense.

SIGMA XI research grants made in varying sums from $100 to $1,000 are now available for 1929–30 for workers in all fields of science, pure and applied. Aid may be given in the form of a fellowship, to purchase apparatus, to help in publication or to pay assistants. There are no restrictions as to the university or the country in which the holder is permitted to work. Application blanks may be obtained from Dean Edward Ellery, national secretary of Sigma Xi, Union College, Schenectady, New York, and should be filed before May 10.

A NATIONAL aeronautic meeting to commemorate the second anniversary of Lindbergh's transatlantic flight will be held in St. Louis from May 27 to 30. The major part of the program is taken up with the third National Aeronautic Division of the American Society of Mechanical Engineers. The remainder of the program consists of an airplane show, May 30 being given over to the finals of the Gardner Cup Air Races. Citizens of St. Louis have financed the Gardner Cup Air Races; the airplane show which will be held without cost to exhibitors; the raising of a fund to make twelve recognition gifts to be presented at the meeting to those who are most deserving of reward for services rendered to aeronautics in the last two years, and the founding of an engraved gold medal to be called the "Spirit of St. Louis," with which medal the society in the future can reward "outstanding services in aeronautics." The meeting will have sixteen sessions, with forty-two papers, divided into general and technical sessions.

GIFTS of $84,757.45 to Columbia University, chiefly for research at the Medical Center, are announced. The Rockefeller Foundation gave $50,000 for research in medical mycology. The Chemical Foundation, Inc., made three contributions. One of $10,000 represented the second payment on its five-year pledge of $20,000 annually for research in the department of biological chemistry. Another of $1,563.18 is to meet the cost of construction changes in that department. The third, of $1,075, is the first quarterly payment on a pledge of $11,900 to cover three years of research in bacteriology. From an anonymous donor came $5,000 for the special tuberculosis fund of the department of the practice of medicine. The General Education Board contributed $4,500 as the fourth quarterly share of its grant of $18,000 for the department of tropical medicine. The International Committee for the Study of Infantile Paralysis added $2,500 to the Bacteriology-Milbank Infantile Paralysis Fund.

ACCORDING to a statement made public by the U. S. Geological Survey, as a result of the season's work in Alaska about 700 square miles of hitherto unexplored territory was mapped geologically and topographically, and 350 square miles, previously mapped in an exploratory way, was remapped and corrected. This work gave a clue to the position and courses of the rivers that drain many thousands of square miles of one of America's great mountain ranges, and to routes of approach to other unexplored areas. The results of this exploration have been issued as a bulletin of the survey, by Stephen R. Capps, in which the geography and geology of the Skwentna River country are described. The report is accompanied by a map on a scale of about four miles to the inch, on which the drainage and the distribution of the rock formations are shown.

UNIVERSITY AND EDUCATIONAL NOTES

Two appropriation bills for maintenance and new buildings for the Pennsylvania State College were passed by the General Assembly in its closing sessions. They amount to $6,311,000 and include $2,250,000 for buildings. The general college appropriation measure, in addition to the building item, would provide $300,000 for agricultural research; $650,000 for agricultural and home economics extension; $711,000 for a deficit, and $2,350,000 for general college maintenance. A separate bill would provide $50,000 for oil research.

E. A. CUDAHY, of Chicago, has given $300,000 to Loyola College for a library building on the campus facing Lake Michigan.

F. L. CARLISLE AND COMPANY, of New York, has made a gift of $100,000 to St. Lawrence University, Canton, New York, payable at the rate of $20,000 a year for five years to be used by the university to promote the teaching of forestry, although its use is not restricted to the formal teaching of that subject in the school.

THE botanical library of the late Frederick LeRoy Sargent, amounting to more than 1,500 volumes and pamphlets, has been given by Professor George Howard Parker to the Gray Herbarium of Harvard University.

DR. GEORGE A. WORKS, dean of the Graduate Library School of the University of Chicago, has been

appointed president of Connecticut Agricultural College at Storrs. Dr. Works will take up his work on July 1. Professor Charles B. Gentry, acting president of the college since the retirement of Dr. Charles L. Beach in July, 1928, will remain as a member of the faculty.

DR. WILBUR WILLIS SWINGLE, director of the department of zoology at the University of Iowa, has been appointed professor in the department of biology at Princeton University.

DR. JOHN SHAW BOYCE, who for fifteen years has been connected with the office of forest pathology of the Bureau of Plant Industry of the U. S. Department of Agriculture, has been appointed professor of forest pathology at Yale University. Dr. Henry Barnard Davis has been promoted to a professorship of geology.

PROFESSOR WILLIAM M. COBLEIGH, head of the department of chemistry and chemical engineering at Montana State College and a member of the staff since 1894, has been appointed dean of the college of engineering and professor of chemical engineering. The appointment is effective on July 1. Professor Cobleigh succeeds Dean Earle B. Norris, who resigned last year to become dean of engineering at Virginia Polytechnic Institute, Blacksburg, Virginia.

DR. FRANK R. MENNE has been appointed head of the department of pathology in the University of Oregon Medical School. He succeeds Dr. Robert L. Benson, who recently resigned.

PROFESSOR B. SMITH HOPKINS, of the University of Illinois, known for his discovery of illinium and work in the rare earths, will be the visiting professor in the department of chemistry of Western Reserve University for the forthcoming summer session from June 24 to August 2. Professor Hopkins will give two series of lectures, one on the "Inorganic Chemistry of the Less Familiar Elements and Their Relation in the Periodic System," and a second course on "The Teaching of Chemistry."

DR. E. H. JOHNSON, head of the department of physics in Kenyon College, Gambier, Ohio, will give lecture courses in the history of physics and thermodynamics at Indiana University during the coming summer session.

DR. H. RAISTRICK has been appointed to the university chair of biochemistry at the school of hygiene and tropical medicine of the University of London.

DR. NOVOA SANTOS, who has been a teacher of general pathology in the University of Galicia, has been appointed professor of the same subject in Central University, Madrid.

DISCUSSION

CLAUDE BERNARD'S CONCEPTION OF THE INTERNAL ENVIRONMENT

PROFESSOR L. J. HENDERSON entitles his valuable recently published book on "Blood" as "A Study in General Physiology," and at the same time treats blood as a physico-chemical system. It may escape notice that he thus makes a very far-reaching fundamental assumption; and the matter is so important that I ventured to bring it before the British Physiological Society on March 16. He refers to the authority of Claude Bernard in justification of his procedure; but in so doing he seems to me to have altogether misunderstood Bernard's conclusion. Bernard was the first to formulate the extremely fruitful idea that the blood of a living animal is an internal medium kept remarkably constant as regards its physico-chemical conditions by the coordinated influence upon it of the various organs of the body. He accepts as fundamental the coordination thus displayed. L. J. Henderson, on the other hand, treats the blood as simply something which, as the result of various "buffer" reactions occurring within itself, is not as readily disturbed in its physico-chemical conditions as other liquids would be. We can, for instance, add a good deal of acid or alkali to blood without much disturbing its reaction. Or if we simultaneously add carbon dioxide and abstract oxygen from it there is a similar diminution of the disturbance which would be produced by either addition of carbon dioxide alone or abstraction of oxygen alone.

These buffer reactions are of great importance and interest, but they were unknown to Bernard, and do not in any way modify his conception of the coordinated activity of organs by which the conditions in the blood are kept constant. This coordinated activity is an essential part of his conception of blood in the living body, whereas L. J. Henderson leaves it out of account, thus turning blood in the living body into what for a physiologist is a mere artifact, and completely disregarding Bernard's principle. It seems to me that if we disregard the coordination we have disregarded all that is characteristic of life, and that therefore the book in question can not be regarded as a study in general physiology, but only as a study in physical chemistry.

To come to details, L. J. Henderson treats the constancy of reaction in the living body as if it depended on the physico-chemical properties of blood. In actual fact this constancy depends during health on the coordinated activity of the kidneys and respiratory organs, in accordance with Bernard's principle; and in various individual parts of the body the constancy depends on the coordinated or regulated influence of the circulation. Not all the buffering in the world

would keep the reaction constant otherwise, though the buffering greatly smooths the regulation. In the human body acid in excess is being continuously produced, partly as ionized sulphuric and other non-volatile acids, and partly as ionized carbonic acid. The formation of acid is constantly being exactly compensated by the excretion of acid urine and formation of ammonia on the one hand, and on the other by the washing out of carbon dioxide through the lungs. The exact coordination or regulation of these activities is the essential matter, and the quantitative investigation in various directions of physiological coordination in recent times has separated the old mechanistic physiology of last century from recent physiology. The normal responses of the kidneys and respiratory organs depend on the simultaneous maintenance of many conditions included under the comprehensive word "health"; but we assume this maintenance in quantitative investigations of physiological function.

If, following L. J. Henderson, we neglect active organic coordination, we are, it seems to me, taking a step backwards. As one who has been closely connected during the last thirty years with the development of Bernard's conception, as well as with the development of knowledge as to the physical chemistry of blood, I wish, therefore, to express my dissent from what appears to me to be L. J. Henderson's misinterpretation of Bernard. In my book, about to be published, on "The Sciences and Philosophy," I have discussed the subject from a wider standpoint, but before I had seen L. J. Henderson's book. It seems to me that apart from the central biological conception of specific coordination we can not make even a beginning in the scientific treatment of general physiology, whether we start from the unicellular organisms which Henderson unjustifiably assumes to consist of a physico-chemical system called "protoplasm," or from compound organisms with a well-defined internal environment between individual cells.

J. S. Haldane

University of Oxford

METABOLIC ACIDITY OR ALKALINITY OF FOODS

It is well recognized that complete oxidation of foods yields mineral residues of neutral, acidic or basic character. These residues are essentially the same as produced by laboratory incineration or by the reactions of metabolism in the animal organism.

Nutritional literature refers to the "acid or base forming tendencies" of foods. Foods are said to have "potential acidity or alkalinity." This "potential acidity or alkalinity" is entirely independent of and distinct from the "acidity" or "alkalinity" of the food in its natural state.

The particular phraseology "potential acidity or alkalinity" lends itself to possible confusion with "acidity or alkalinity," or at least does not make the distinction as apparent and distinct as it might be. It is proposed that a more exacting terminology be adopted for "potential acidity or alkalinity."

"Potential *metabolic* acidity or alkalinity" or more simply still "*metabolic* acidity or alkalinity" seems to define appropriately and specifically the reaction character of food mineral residues subsequent to the reactions of metabolism. The "metabolic acidity" and the "acidity" of a food are not subject to confusion or interchange even to the superficially tutored.

Raymond Hertwig

THE OCCURRENCE OF BOTHRIOPLANA IN THE UNITED STATES

In a note to Science on the occurrence of *Otomesostoma* in this country, published in the October 12, 1928, issue, mention was made of the existence in this vicinity of several unidentified rhabdocœles thought to belong to the subclass Alloiocœla. Since that time I have definitely identified one of these as *Bothrioplana*.

Individuals of this genus have been known to this laboratory for three years, but had not been studied in detail until this fall. They occur in abundance in the outlet of the University of Virginia gymnasium pool, where the water is swift and clear; and in a branch from a spring on the adjoining golf course. The specimens are large, and may easily be mistaken for a species of *Planaria*.

Under laboratory conditions the animals have produced three eggs each in a single period of sexual maturity. The eggs are large, 390 micra in diameter, and unstalked. The embryos develop in twenty-one days at room temperature and emerge through an operculum at one pole. Work is in progress on the histology of some of its organs of special sense. This is the first record of this genus in the United States. Stienböck, in a recent paper entitled "Beiträge zur Kenntnis der Turbellarienfauna Grönland," 1928, has included it in the fauna of Greenland.

J. S. Carter

University of Virginia

AN UNUSUAL SOURCE OF LIVING MATERIAL

In most localities that have winter seasons during which the temperature drops below freezing, it is probably not ordinarily possible in these months to collect living specimens of microscopic forms of life. This is especially true of those places that have winter climates that may be called rigorous. From all accounts the winter season just closing has been uncommonly severe. Here at Gunnison, which may be taken

as largely typical of the high Rocky Mountain regions, temperatures have been unusually low. From about December 1, 1928, to March 1, 1929, the greater part of the time was at subzero temperatures. During December and January the temperature was mostly at subzero levels, often for as long as two weeks at a time. Milder temperatures (up to 30° to 40° above zero) were relatively infrequent and only occurrent in the daytime. The coldest period (47° below zero) occurred in February. However, it has been possible to collect living *Protozoa* and *Algae* under these conditions. About a half mile south of the college campus is a swampy area of several acres in extent that is fed with water that flows from underground. The source of this water is not definitely known, but perhaps it comes from warm areas below strata that lie buried from several hundred to several thousand feet under the high mountains to the north. A swiftly flowing stream about four or five feet wide and about one foot deep drains this swamp. At no time does this water freeze, not even when the temperature of the air is as low as 47° below zero. A curious circumstance is that such floating forms as duckweed can be found in the fully normal condition. Higher water plants are abundant. *Algae* such as *Chlamydomonas* and various filamentous forms may be collected at any time. *Amebae* of several types are to be found creeping about in material taken from the bottom. By far the most common form of *Protozoa* is *Vorticella*. *Euglena* is also rather common. No specimens of *Paramecium* have been noted in this material, but a few ciliates resembling *Colpoda* are to be seen.

Perhaps this condition is not so unusual as may appear at first sight. If other biologists who live in a "frigid" winter climate look about them, many such sources of living material for winter study may possibly be found.

C. T. Hurst

Western State College of Colorado

QUOTATIONS

DORMITORY OF THE NEW YORK MEDICAL CENTER

When the Medical Center was dedicated last October, Dr. Samuel Lambert stated that, while the buildings met the complex requirements of an art and a science, there was one thing lacking. That was provision for the home life of the students of medicine and instructors, especially the young workers in the laboratories. Such a provision would be an innovation but it would help to foster a professional spirit and to round out professional life if dormitories and a common dining hall could be added to the buildings already developed or planned for in that monumental center. He spoke with seeming prescience, though doubtless not knowing at the moment how the need would be met. It has found response in the splendid gift of Mr. Edward S. Harkness, who, with his mother, made initially possible the Medical Center itself. This gift of $2,000,000 will now supply "the one thing lacking."

No one need fear, as Dr. Lambert said, that such an addition will lead to anything approaching cloistered life. Contacts with the outside public are inevitable both for teachers and students. They are simply assured a "quiet, commodious and comfortable home," with light and air and an outlook over the Hudson River, in close proximity to the Medical School and the associated hospitals. Heretofore, as President Butler said in acknowledging this latest munificence of Mr. Harkness, the residence conditions of medical students have been little short of scandalous. The conditions made possible by this gift will by contrast be ideal.

The indebtedness of Columbia University to Mr. Harkness is profound, but the whole community shares in it, and not this community alone; for the Medical Center is also to be more and more a world center of medical training, care and research. What Mr. Harkness has done in varied ways, not only for his own day and generation but also to help this generation make a greater contribution to the next, may be computed in dollars given, but it is beyond all computation in the saving and enriching of human life. New York has reason to congratulate itself upon the public-spirited, conscientious and intelligent way in which most of those who have come into great fortunes are contributing to the general good. So generous is their concern for the health, safety, comfort and education of the many that it can but be hoped that the miracle of the cruse of oil and the meal in the barrel will be continued to them.—*The New York Times.*

SCIENTIFIC BOOKS

The Ways of Behaviorism. By John B. Watson. Harper Bros., 1928.

Psychological Care of Infant and Child. By John B. Watson. W. W. Norton Co. 1928.

The Battle of Behaviorism. By John B. Watson and Wm. McDougall. W. W. Norton Co. 1929.

I shall use the present occasion not to present in summary the contentious content and tone of the recent writings of Dr. John B. Watson—which may be assumed to be familiar—but to discuss the "ways

of behaviorism" as a logical position and a propaganda for popular recognition—all in its bearing upon certain issues in scientific procedure.

The situation is unprecedented and perhaps could not occur in any other science than psychology, or in any other land than America. Psychology has had a long and hard struggle to achieve scientific recognition. The movement began with the foundation of the psychological laboratory now celebrating its jubilee year appropriately by convening the International Congress of Psychology for the first time on American soil. It remains true that the methods and results of the laboratory constitute the major warrant for the unreserved acceptance of psychology in the fraternity of the sciences. The difficulties surmounted in that achievement were formidable. The intellectualist attitude, derived from long association with the discipline of philosophy academically formulated, was but slowly outgrown. The dangers of a program too rigidly conceived as the experimental version of the older types of problems were real, but avoided. In that consummation the broad interests and versatile originality of William James had no small share.

Quite as influential as the experimental reformation was the biological restatement of the entire range of human traits and their origin and significance. Without Darwin that would have been impossible. Galton was a pioneer in the field. Its most direct expression resulted in the complete restatement of the problems of animal intelligence. Thorndike's contributions led the way on the part of American psychology; Watson was a notable follower; Yerkes has carried the pursuit to its richest results. The similar reconstruction—almost a complete foundation *ab ovo*—of child psychology is of equal importance in bringing about the present acceptance of psychology as a scientific discipline. Stanley Hall was the leader of the movement; the work of Terman in one direction, that of Gesell in another, may stand as representative of the present-day fruitage of scientific method in this domain.

Clinical psychology is an equally important partner in the scientific renaissance of psychology. For the present reference it is more germane to call it so than by the more general name of abnormal psychology,[1] which better indicates its domain, to emphasize the source of the advance in the clinical attitude in the study of psychic variation. As such it is an application—one of many—of the reconstruction of psychology to vital problems of adjustment. Industrial psychology is another; educational psychology still another; criminal psychology yet another.

The inclusion of the racial and the social problems of human variation in endowment and achievement, companionating psychology and anthropology, is of comparable importance. An additional concluding reference may be reserved for the specific rapprochement of the biologist and the psychologist, notably in the study of heredity and environment in their bearing on mental traits.

To all this jointly and collectively we owe the position of vantage of present-day psychology—a product of the last fifty, for the most part of the last twenty-five, years. And all of it—certainly almost all of it—was inspired and directed by the view of psychology as the study of human behavior. It is 90 per cent. if not 100 per cent. behavioristic, yet was accomplished not by so-called (Watsonian) behaviorists but by the contributions of scientifically minded psychologists who gave to that phase of "behaviorism" for which Watson claims a proprietary right, precisely the recognition it deserved.

For any one, whatever his attainments or achievements, to make the presumptuous gesture of claiming for his variety of "behaviorism" or any other "ism" the sole warrant of science, to discard all the labors of his fellow psychologists as misguided rubbish, to inform the many workers in the field of heredity that they are on a false scent and to repeat the information to the psychiatrists, to predict that in a few years under the adoption of a Watsonian behaviorism all the important problems will be solved, to set forth a new dispensation, contrasting the darkness and futility of all psychology before 1912 (this is the Messianic year that Watson has adopted for his era) and the subsequent light (without sweetness), to mislead and misguide the public by misrepresenting the positions of fellow psychologists as continuing the "soul" psychology of an obsolete tradition—all this disqualifies any member of the scientific guild from the consideration to which his previous scientific contributions—as in the present instance—may have amply entitled him.

The earlier period of Watson's psychological career was a period of contribution, not of presumption. But from the popular lectures on "Behaviorism" and in increasing measure in the books here cited, the strident, advertising tone of irresponsible statement at times gives way to, at times flaunts and overrides the scientific contributions that continue to be scattered among his cavalierly pronouncements.

It is only in the perspective of fifty years of psychological progress that the bearing of this unpre-

[1] I have omitted from this summary the specific mention of the Freudian approach—in one respect the most influential factor in compelling the recognition of psychology—because it may be included in abnormal psychology and because it is better to avoid the issue of its scientific foundation. As a component of our present-day insight into human behavior its influence is momentous.

cedented situation becomes apparent. If any such extravagant and irresponsible claims, coupled with such lordly and superman-ic disdain for one's fellow scientists, issued from a man of slight consequence and no standing, it would be easy to ignore them and await their oblivion with unconcern. But Watson's standing is unchallenged, his ability exceptional, his contributions notable.[2] If some modern scientific Machiavelli had devised a course to confound the world, he could have done nothing shrewder. First establish yourself as a man of science, make contributions that command respect, then with the prestige of such authority throw the labors of every one else into the discard, announce the new era of your own reforms and proceed in triumph.

But that procedure was made possible only by the most distinctive product of American civilization (or the lack of it)—advertising. "Behaviorism" (à la Watson) has a small but unmistakable scientific following; it deserves it. Its most notable representative is Lashley, whose conclusions are presented with scientific precision, free from any pretense or glamour. The vast majority of behaviorists decline to subscribe to the suicidal curtailment of their science which Watson advocates. Watsonism of the later period has not made its way by scientific endorsement but by popular appeal. The editors of popular magazines are the sponsors of this "Behaviorism." It made good copy, and they put it over. It is foolish to ignore this situation, though there is no need to become unduly excited about it. But it is important for psychologists to have their co-scientists in other fields understand the situation. It is a matter of serious concern that this untoward incident in the neohistory of American psychology has occurred. Its effect on the prestige of psychology in America is unfortunate.

I shall believe as long as I can that Watson is sincere in his views and has only the interests of truth in mind, though the belief involves a logical strain, since the evidence of Watson's intellectual ability is convincing. But this as well as my appreciation of the important place that he occupies among contemporary psychologists must give way to the plain duty of placing on record the actual situation (as I see it) which an unprecedented method of circulating scientific conclusions has precipitated upon an otherwise quite sufficiently troubled science. Psychology, however, is not in a precarious position. It will survive the "strange interlude" of "Behaviorism" and pursue its proper and profitable behavioristic career.

JOSEPH JASTROW

[2] Inasmuch as I used Watson's earlier book as a text in "Animal Psychology" so long as I conducted that course, my own appreciation is on record.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE ANALYSIS OF DILUTE SOLUTIONS OF METHYL ALCOHOL

In the course of an investigation of the degree of hydration of sucrose under J. W. McBain, it became necessary to find a method for the analysis of methyl alcohol solutions that should be much more accurate than the customary distillation and determination of the density of the distillate, and at the same time should be easily and rapidly performed.

A review of the available methods revealed none that was suitable, so that it became necessary for me to devise my own procedure.

Among the various suitable reactions, oxidation by chromic acid proved most suitable. Numerous analytical procedures have been devised based on the ease with which chromic acid is reduced in the presence of sulfuric or phosphoric acid. See, for example, *Nature,* 122: 903, 1928, and especially *Biochem. Zeit.,* 170: 18, 1926. In the latter reference is listed a large number of compounds subject to quantitative oxidation with chromic acid. The usual methods of determining the quantity of chromic acid consumed are, however, inconvenient, to say the least.

My procedure for methyl alcohol (and by modification it is applicable to a great variety of analyses) is as follows: The dilute solution containing the alcohol is distilled unless it is known that there is no other oxidizable substance present. All of the methyl alcohol will be removed in the first half of the distillate. An aliquot sample is placed in a 125 ml Erlenmeyer flask and an excess of sodium dichromate solution added. The whole is made 12 normal with sulfuric acid. It is convenient to have the acid and dichromate solution mixed in such a proportion that after the sample is added the acid normality will not be less than 12. The flask is then corked loosely and heated on a water bath for ten minutes. The flask is then cooled, the contents washed into a beaker and the excess dichromate determined by titrating with ferrous sulfate, determining the end point electrometrically. A smooth platinum electrode is used in the solution, the circuit being closed through a salt bridge to a calomel electrode. When the last drop of ferrous sulfate is added, the registered potential drops between two and three tenths of a volt, making an exceedingly sharp indication of the end point. Needless to say, if one passes the end point it is easy to titrate back.

The accuracy of the method is limited only by the accuracy and precision of the volumetric measurements and apparatus. I have found it not at all difficult to determine the alcohol content of a 10 ml

sample of 1 per cent. solution with an error not greater than 0.2 per cent. of the weight of the alcohol.

S. S. KISTLER
COLLEGE OF THE PACIFIC

A SIMPLE BURNER FOR NATURAL GAS

WHEN natural gas arrived at New Orleans we found every Bunsen burner in the laboratory practically useless. They yielded a long, soft, non-roaring flame with no inner cone, which would not allow even simple bending of soft glass tubing. While there are probably excellent natural gas burners on the market, a very crude home-made device has proved so useful to us that it may be of interest to others who are encountering the same difficulties.

Fig. 1

A medicine dropper (A) with a fairly narrow aperture is attached to the gas supply and supported vertically in a burette clamp. A metal tube (B) about one half inch in diameter and seven or eight inches long (a section of common iron gas-pipe serves admirably) is similarly fixed just above the tip of the dropper. By proper alignment and up-and-down adjustment a very hot roaring flame with a good cone is obtained. The unimpeded air inflow is perhaps the explanation.

TULANE UNIVERSITY C. REYNOLDS

SPECIAL ARTICLES

GLUTATHIONE IN PLANTS[1]

FINK[2] in 1927 published a micro method for the determination of glutathione in insect tissues. Since that time the writer, at various times and with considerable success, has applied this method to his study of reproduction and sexual differentiation in plants. The study of glutathione seems important, for this dipeptide complex apparently has actual functions in the metabolism of the cell.

In making a determination the writer heated thin sections of fresh tissue in dilute acetic acid. They were then washed in a saturated solution of ammonium sulphate $(NH_4)_2SO_4$, and placed in a watch glass containing about 5 cc of the same solution. Five to fifteen drops of a 5 per cent. solution of sodium nitroprusside $Na_2Fe(CN)_5\ (NO)2H_2O$ were added to the ammonium sulphate, and after a short while, time being allowed for thorough agitation and diffusion of the chemicals into the tissues, about 1 cc of ammonium hydroxide was added. On addition of the last, a color between pale pink and magenta flashed in the cells, and lasted from a few seconds to several minutes. The intensity and time of duration varied, presumably with the relative amount of glutathione.

The writer made observations of various species of plants. The following examples are sufficient to show the general results.

Longitudinal sections of the stem apex of young sunflowers (*Helianthus annuus*) were treated. The apical region of cell division flashed red, shading off into pink in the older region of cell elongation. Below this there was little or no color in the pith. However, two brilliant streaks extended downward from the apical region of cell division into and along the cambium, becoming a paler pink in the actively conducting phloem. In older plants, of the age when the stem apex had flattened out to form the disk, the reaction was much the same as that in the younger plants except that the brightly colored cells no longer formed a mass within the apex, but were distributed at the upper edge of the disk, the color being extremely intensified in the papillae which would later become individual flowers. In the next stage, during early development of the flowers, the tissues associated with the stamens showed pink, and the carpellate structures a fainter pink. Just before the opening of the flower bud, the staminate portions containing mature pollen showed practically no reaction, while the carpellate structures in their last stages of development showed pink ovularies and bright red ovules.

In the monosporangiate Arum (*Alocasia odora*) studies of the developing spadix showed a consistently more intense reaction in the staminate, or male, portion than in the carpellate, or female, portion of the axis.

Under controlled conditions corn (*Zea mays*) may be induced to produce plants with normal staminate tassels, with mixed tassels, with apical ears bearing functional carpels, or with a completely sterile apex.[3] Studies with the nitroprusside test indicated that the more intense reaction was in the tissues of plants having normal staminate tassels, and the least intense in the plants with a sterile apex, with an intermediate reaction in plants having a female, or carpellate, inflorescence at the apex.

The nitroprusside reaction, indicating glutathione, is thus helpful as an indicator of certain chemical reactions in cells, and may be used to advantage in measuring the metabolic level of various tissues during the ontogeny of the plant.

W. H. CAMP
DEPARTMENT OF BOTANY
OHIO STATE UNIVERSITY

[1] Paper from the department of botany, the Ohio State University, No. 236.

[2] Fink, SCIENCE, 65: 143, 1927.

[3] J. H. Schaffner, "Control of Sex Reversal in the Tassel of Indian Corn," *Bot. Gaz.*, 84: 440, 1927.